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Dairy Crossbreeding Research: Results from Current Projects

Bennet Cassell, Professor and Extension Specialist, Dairy Science, Virginia Tech
Jack McAllister, Extension Professor, Animal Sciences, University of Kentucky

Many dairy producers practice some crossbreeding, and the numbers increase every year. Motivating factors include a desire to improve fertility, survival, milk components, and calving ease. Some producers want cows smaller than mature Holsteins. Several large, long-term dairy crossbreeding experiments have been conducted in the United States in the past. Cows involved in previous projects were not the result of intensive selection programs for type and production that produced today's purebred populations. Producers need information about the performance of different breeds for economically important traits as well as for good estimates of heterosis from specific crosses for those same traits. The renaissance of interest in crossbreeding in the U.S. dairy industry motivated several research groups to develop crossbreeding trials. These projects are maturing and a body of information is beginning to form. This publication summarizes the results to date.

Institutional-herd breed projects are in progress at five universities in the U.S. Additional information from commercial dairy herds is now available. All of the work highlighted here is based on performance under U.S. confinement systems.

Current crossbreeding trials in the U.S.

- California commercial herds (7) bred purebred Holstein cows to Normande, Montbeliarde, and Scandinavian Red sires in AI. This is the most mature of the crossbreeding trials and involves several hundred cows. Minnesota scientists have monitored and summarized the performance.
- Holstein-Jersey crosses vs. purebred Holsteins in Minnesota – first calves were born in 2001. A full report is expected in early 2008, but results in this report are from June 2007 abstracts at the American Dairy Science Association meeting. Montbeliarde and Swedish Red sires are used on the Jersey-Holstein crossbred dams to produce the second generation.
- A "backcross" trial at Wisconsin with Holsteins bred to crossbred Holstein-Jersey bulls in AI producing 75 percent Holstein crossbreds. First calves were born in 2004. Crossbreds are bred back to Holstein sires to produce 7/8 Holsteins in the second generation.
- A "diallele cross" experiment at Virginia Tech, Kentucky, and North Carolina State where eight foundation Holstein and Jersey sires were bred to purebred Holstein and Jersey dams. First calves were born in 2003. Crossbreds at Virginia Tech and Kentucky are bred to Brown Swiss and Swedish Red sires in the second generation. A two-breed rotational system is followed at North Carolina State using Holstein and Jersey sires only.
- Holstein and Brown Swiss crosses and purebreds in 19 commercial herds, summarized by researchers at Penn State and Tennessee included some backcrosses to Brown Swiss to estimate "recombination effects."

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California commercial herd results

Table 1 shows cow performance for purebred Holsteins and crosses of Normande (a French dairy breed), Montbeliarde (a French dairy breed), and Scandinavian Red bulls on purebred Holstein dams. Highest production was for purebred Holsteins, but milk yields from the Montbeliarde and Scandinavian Red crosses were close to Holstein, with higher components. Combined fat and protein volume (not shown in the table) for Scandinavian Red-Holstein crosses was not significantly lower than purebred Holstein cows. The small differences in yield mean that even small advantages in fitness and fertility will make crossbreds financially appealing.

Table 1 also includes calving records of purebred and crossbred cows. Dystocia (calving difficulty) and stillbirths (calf mortality) were greatest for purebred Holstein mothers at 17.7 percent and 14.0 percent. Dams sired by Montbeliarde and Scandinavian Red sires experienced significantly less dystocia and fewer stillbirths than purebred Holstein dams. Normande-Holstein crosses did not differ from purebred Holsteins for stillbirths, but had less dystocia.

Table 2 shows calving difficulty and stillbirth results by breed of sire when used on first-calf Holstein dams. Scandinavian Red bulls produce significantly less dystocia and fewer stillbirths in their calves than Holstein sires. Brown Swiss bulls produce less dystocia than Holstein bulls. The Scandinavian Red breed shows clear advantages in both dystocia and stillbirths from these results. Selection programs in the Scandinavian countries have emphasized reduction in dystocia and stillbirths for about 30 years. Many dairy producers across the U.S. are using Scandinavian Reds on Holstein heifers because of calving ease and calf survival.

Table 3 includes survival and fertility data on cows in the California trial. Crossbreds were more likely to survive through 305 days of first lactation than were the purebred Holsteins. There were no statistically significant differences between the four breed groups for days open, but the first-service conception rate was significantly higher for crossbreds. The most fertile breed group was the Normande-Holstein cross, and Montbeliarde and Scandinavian Red crosses were also significantly lower for days open than purebred Holsteins. Normande-Holstein crosses were the lowest producers in Table 1, which demonstrates an important reality. High production and high fertility are hard to accomplish together, as there is a genetic antagonism between these two traits. We need to develop dairy cows that produce at profitable levels, regain energy balance quickly after calving, and retain enough body tissue reserves to breed back in a timely manner.

Table 1. California trial: comparisons of yield and calving performance.

	Breed of cow			
	Holstein	**Normande-Holstein**	**Montbeliarde-Holstein**	**Scandinavian Red–Holstein**
Number of cows in milk	380	245	494	328
Milk, lbs	21,510	18,805*	20,196*	20,460*
Fat %	3.55	3.74	3.65	3.66
Protein %	3.13	3.25	3.20	3.20
Number of calvings	676	262	370	264
% calving difficulty**	17.7	11.6*	7.2*	3.7*
% stillbirths**	14.0	9.9	6.2*	5.1*

*Crosses differed from Holsteins (P<0.05). The paper reported volume of components, so component percentages were not tested for significance.

**Average dystocia and stillbirth rates are from first calvings when cows were bred to Montbeliarde, Brown Swiss, or Scandinavian Red bulls.

Table 2. California trial: performance of breed of sire when used on first-calf Holstein dams.

	Breed of sire			
	Holstein	**Montbeliarde**	**Brown Swiss**	**Scandinavian Red**
Number of calvings	371	158	209	855
% calving difficulty	16.4	11.6	12.5*	5.5*
% stillbirths	15.1	12.7	11.6	7.7*

*Different from Holsteins (P<0.05)

Table 3. California trial: survival and reproduction by breed combination of first lactation cows.

	Holstein	Normande-Holstein	Montbeliarde-Holstein	Scandinavian Red-Holstein
Number of cows	523	363	229	190
% surviving to 305 days	86	93*	92*	93*
Number of cows for days open	520	375	371	257
Average days open	150	123*	131*	129*
Number of cows for conception rate	536	379	375	261
First service conception rate (%)	22	35*	31*	30

*Different from Holsteins (P<0.05)

The California trial is the first to compare purebred Holsteins to crosses of some European dairy breeds. It gives important new information, but needs to be interpreted with some caution. The herd owners who participated decided to move away from purebred Holsteins before the trial began, not after. The crosses themselves were novel animals. Consequently, the Holsteins and crosses may have been treated somewhat differently than will be the case in herds that repeat such matings in the future. The results are based on several hundred animals, not many thousands of animals, as are used to evaluate merit of U.S. pure breeds. Finally, the traits studied are those expressed relatively early in life. Some of the important questions about crossbred-purebred performance relate to performance in mature animals. We have more to learn about European breeds under U.S. management conditions.

Holstein-Jersey crosses at Kentucky and Virginia Tech

The Holstein-Jersey crossbreeding project at Virginia Tech and the University of Kentucky was started in 2002. North Carolina State also participates in this project, but animals there are younger and did not contribute to results reported here. First calves were born in 2003, and the first calvings for project animals were in June 2005. The project animals included in these preliminary results are those old enough to contribute to the various kinds of performance data.

Table 4 compares the four breed groups for birth weights and dystocia of calves. No significant differences were found between calves born to the four breed groups for stillbirths, so those results are not shown. Birth weights differed for all four breed groups, with purebred Holsteins producing the largest calves, as expected. Jersey sired calves out of Holstein dams were larger than Holstein sired calves out of Jersey dams, suggesting a breed-of-dam effect on birth weights. Dystocia scores were highest for calves sired by Holstein bulls. Jersey dams had as much difficulty giving birth to Holstein sired calves (the HJ group) as did Holstein dams (the HH group). Conversely, Holstein mothers were equally good as "easy calvers" as the Jersey dams when Jersey bulls sired the calves they carried.

Table 4. Comparisons of 414 birth weights and 421 dystocia scores by breed group in the Virginia Tech – Kentucky crossbreeding study.[1]

	Breed group of calf (sire breed first)			
	HH	HJ	JH	JJ
Birth weights (lbs)[2]	88[a]	65[b]	69[c]	50[d]
Dystocia (1 to 5 scale)[2]	1.7[a]	1.6[a]	1.2[b]	1.2[b]

[1]Stillbirth percentages did not differ by breed group of calf born.

[2]Means with different superscripts are significantly different (P<0.05)

Another way to analyze calving difficulty is to ask the question "Is the risk of dystocia or stillbirth the same for different breed groups?" The results are expressed as odds ratios – relative risks for the different breed groups. We can also use the breed comparisons in a different way that may be more informative to some producers about the value of crossbreeding. Holstein and Jersey genes for dystocia or stillbirths have one set of effects on the calf, but a separate effect on the mother. These effects are called "additive" and "maternal" effects. A third effect, heterosis, results from combinations of genes from different breeds. These separate genetic effects are shown in Table 5. Stillbirths are included because this approach of examining additive, maternal, and heterosis effects showed differences between Holstein and Jersey gene sources. The stillbirth differences cancelled out in the breed group comparisons, and were not included in Table 4.

Holstein genes in calves are 34.9 times more likely to cause dystocia at birth as Jersey genes in calves. However, Holstein genes in the dam (maternal effects) are only 30 percent as likely to cause dystocia or stillbirths as Jersey maternal genes. The difficulty caused by additive effects of Holstein genes is much greater than the maternal advantage. Dairy farmers will certainly have fewer overall dystocia problems by adding Jersey genes to a crossbreeding program than by adding Holstein genes. There is no heterosis for either dystocia or stillbirths in this preliminary study when using Holsteins and Jerseys in the crossbreeding system. About 25 percent more calf births will be added to these results in a final analysis.

Table 6 compares production data from 106 first-lactation cows at Virginia Tech and Kentucky. This group is about 40 percent of all animals that will ultimately contribute to the project. Final results may tell a somewhat different story.

HJ and JJ groups produce significantly less milk than purebred Holsteins, but JH and HH groups are not different for milk yield. Holsteins and crosses are not different for fat and protein yield. Jerseys do not produce as much as Holsteins or crossbreds for any of the traits in Table 6. These 16 purebred Jerseys are not equally distributed across the four Jersey bulls used for the project. The lower ranking bulls are more heavily represented. Subsequent analysis with additional data may reduce the differences between pure breeds.

Minnesota Holstein-Jersey trial

A preliminary analysis of the Minnesota Holstein-Jersey trial showed that Holsteins produced significantly more milk and protein than JH crosses in the first lacta-

Table 5. Risk (odds ratio) of dystocia or stillbirths from additive or maternal effects of Holstein versus Jersey genes or heterosis (crossbred versus purebred calves).[1]

Gene effect	Odds ratio for Holstein vs. Jersey genes	
	Dystocia	Stillbirths
Additive	34.9	5.9
Maternal	0.3	0.3
Heterosis[2]	1.4	1.0

[1] Odds ratio greater than 1.0 indicates a greater risk of dystocia or stillbirths from Holstein genes than from Jersey genes.

[2] Heterosis was not significant for dystocia or stillbirths.

Table 6. Comparisons of yields for Holsteins, Jerseys, and reciprocal crosses in the Virginia Tech – Kentucky crossbreeding project.

Trait	40 HH cows	27 HJ cows	23 JH cows	16 JJ cows
305d actual milk, lbs	21,579	18,935**	20,419	15,244**
305d actual fat, lbs	806	863	806	703**
305d actual protein, lbs	645	643	643	500**
Peak milk, lbs	81	78	76	55**
Summit milk, lbs	74	68	70	53**

* Based on 122 cows that have freshened
** Different from Holsteins (P<0.05)

tion. Fat yield was not different for the two groups. JH crosses had significantly less udder clearance (measured distance from floor of the udder to the milk parlor floor) than Holsteins. Front teat placement and teat length was not different from Holsteins. Days open averaged 136 days for JH crosses and 159 days for Holsteins. A higher percentage of crossbreds calved a second time (87 percent vs. 77 percent). There was no indication in the published document that the fertility and survival were significantly different between the crossbreds and Holsteins. More detailed results of this project will be available in 2008.

Wisconsin "backcross" trial

Wisconsin mated purebred Holstein cows to Holstein-Jersey crossbred bulls, producing a backcross to the Holstein breed (relative to the crossbred bull). Both breed groups were scored as part of the Holstein Association type evaluation program. The JH crosses were shorter and stronger than Holstein contemporaries, with lower dairy form scores, steeper foot angle, and more slope to more narrow rumps. Udder traits were not different, except for closer front teat placement in the crosses. In an evaluation of calving traits for purebred and crossbred cows, greater dystocia and higher stillbirth rates were reported among Holstein sired calves born to the three-quarter cross dams than for pure Holstein dams. The crossbred dams had trouble giving birth to 7/8-Holstein calves. Some dairy producers have Holstein-Jersey crossbred sires to reduce calf size and dystocia. There is a price to pay for that practice when the resulting calves mature to deliver Holstein-sired calves.

Results for Holsteins and Brown Swiss

Researchers at Penn State and the University of Tennessee summarized records from 19 dairy farms in the United States with Holsteins, Brown Swiss, both possible F1 crosses, and backcrosses. Only results from the use of Brown Swiss sires on Holstein or crossbred dams are reported because only a few Holstein-sired crosses out of Brown Swiss dams were available. All animals included in the results below were required to have a registered Holstein or Brown Swiss sire and a properly identified maternal grandsire. The goal of these edits was accurate breed composition. Results are for first and later lactations, adjusted for age effects.

The F1 crosses, sired by Brown Swiss bulls out of Holstein dams, were not significantly lower in milk yield than purebred Holstein cows, and were significantly higher in protein yield. Fat yield of crosses was numerically but not significantly higher than Holsteins. F1 crosses had significantly fewer days open than Holsteins and were numerically but not significantly lower in age at first calving. The conclusion is that Brown Swiss–Holstein crosses have been very competitive with Holsteins in these herds for several economically important traits.

Backcrosses to Brown Swiss bulls have not performed as well as the F1s. Milk yield was significantly lower than Holsteins or F1s and age at first calving was higher. The genetic term for this effect is "recombination loss." The theory is that certain favorable gene combinations in pure breeds are "fixed," that is, they don't vary from

Table 7. Least Squares means, percent heterosis, and recombination loss for Holsteins, Brown Swiss, and crosses of the two breeds.

Trait	HH*	BH	B(BH)	BB	% heterosis	% recombination loss
Number of cows	1773	132	85	805		
ME Milk, lbs	24,747	24,520	22,295**	21,695**	5.6	-3.5
ME fat, lbs	873	915	849	833	7.2	-2.9
ME protein, lbs	725	772**	714	699**	8.5	-3.1
Days open	156	144**	153	156	7.3	-2.1
SCS	2.75	2.82	2.57	2.59	7.8	4.1
Age at first calf (mo)	25.8	25.3	26.7**	26.7**	3.5	-2.3

*HH – Holstein, BH –Brown Swiss sire, Holstein dam, B(BH) - backcross to a Brown Swiss sire, BB – Brown Swiss

**Significantly different (P<0.05) from Holsteins one generation to another. These genes interact in ways favorable to performance. F1 crosses are not affected by recombination loss because half the genes are transmitted intact from each purebred parent. The important gene combinations are undisturbed. However, the F1 creates sperm and egg cells that include sample halves of genes from two breeds, breaking down some favorable gene combinations. Table 7 shows unfavorable recombination effects for all of the traits. The recombination loss in Table 7 is only for the Holstein breed, as the use of a Brown Swiss purebred sire preserves favorable gene combinations from that breed. Notice that all effects of heterosis in the F1s are favorable and are larger than the recombination loss.

Recombination loss is very difficult to estimate statistically. Table 7 includes data on 85 backcross cows. Thus, recombination loss is poorly estimated in this study. There may be other explanations for poorer than expected performance of the backcross cows and additional research is needed to verify or refute these results. However, recombination loss is one of the risks that dairy farmers accept when they initiate crossbreeding programs. This is the first evidence of recombination loss in recent dairy breeding literature. It is highlighted here to present a more complete story. The other results in Table 7 are supportive of Brown Swiss-Holstein crosses.

Select the best sires available for crossbreeding programs

Herds using crossbreeding systems should select purebred bulls just as carefully as for purebred programs. The literature does not support use of crossbred bulls in crossbreeding programs. Benefits of selection within pure breeds are just as important for crossbred programs as for purebred programs. There is no justification to use unproven and/or unselected bulls of a different breed. Some herds have used Jersey bulls in natural service as calving ease bulls on Holstein heifers. Calves born from these mating will not benefit from selection, as their sires were unproven at the time of use. Performance of such crosses will be affected, and judgments of the value of crossbreeding programs will be distorted. Always use carefully selected, reliably proven bulls for AI in crossbreeding programs.

Conclusions

This publication includes many partial reports of research work currently in progress. We do not have the benefit of completed research projects, replicated results, or of widespread field experience by commercial producers. This publication is intended to be an interim source of information to be replaced later by more complete work. Following is an interpretation of current results, all subject to change or at least restatement.

1. Crossbreds produced using European dairy breeds, particularly Montbeliarde and the Scandinavian Red group, are very promising. Swedish Reds in particular appear to perform well in reducing dystocia and stillbirth incidence.

2. Brown Swiss–Holstein crosses have performed very well, with milk yield only slightly below purebred Holsteins with higher components and fewer days open.

3. Holstein-Jersey crosses will be born with ease from Holstein dams and will produce well, especially for component milk markets.

4. Fertility results indicate an important advantage to Holstein-Jersey crossbred cows.

5. There is growing evidence that udders of Holstein-Jersey crosses can be too deep to milk conveniently or to avoid injury and mastitis. Pay special attention to udder depth and teat placement in choosing Holstein or Jersey sires for crossbreeding programs.

6. Component yields, fertility, and partial herd-life survival data suggest that crossbreds of Holsteins and Jerseys should compete well with or exceed purebred Holsteins for lifetime economic merit, especially in milk markets paying for both fat and protein.

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